

Longitudinal Behavioral Effects of a School-Based Fruit and Vegetable Promotion Program

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Objective This study examined the longitudinal effects of a school-based program on kindergarten and first grade children's fruit and vegetable (F&V) consumption. **Methods** The program included lunchroom, classroom, school-wide, and family components. The primary dependent variable, F&V consumed at lunch, was assessed using weighed plate waste. Hierarchical linear models were used to analyze the differences between intervention and control groups and to account for repeated measurements. **Results** Children in the experimental group consumed more F&V ($F = 29$ g; $V = 6$ g; 0.43 portions/lunch; 0.28 servings/lunch) at the end of Year 1 compared with children in the control group. At the end of Year 2, children in the experimental group consumed more fruit (21 g; 0.23 portions/lunch; 0.15 servings/lunch), but not more vegetables compared with children in the control group. **Conclusions** The intervention resulted in increased F&V consumption, with more pronounced and enduring effects for fruits than vegetables.

Fruits and vegetables (F&V) are important components of healthful diets. Despite calls for increased F&V consumption (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2005), one study found that over 95% of black and white girls failed to meet the Healthy People 2010 recommendations for fruit and vegetable intake on even a single day (Striegel-Moore et al., 2006). Schools can play an important role in the promotion of healthy eating (IOM, 2005, 2007), with ~28 million children participating in the National School Lunch Program (IOM, 2004). Regulations governing this program require that schools serve at least two fruits or vegetables each day in the school lunch (Code of Federal Regulations, 2007).

A number of researchers have focused on school-based promotion of F&V consumption. Knai, Pomerleau, Lock, and McKee (2006) conducted an international research review of interventions designed to promote F&V consumption among school-aged children. Of the 15 studies designed to encourage children to eat more F&V, 10 had significant positive effects on students' consumption. Given the importance of promoting F&V with

young children (Kelder, Perry, Klepp, & Lytle, 1994) surprisingly, only three studies included children under third grade (i.e., Auld, Romaniello, Heimendinger, Hambidge & Hambidge, 1998; Horne, Tapper, Lowe, Hardman, Jackson, & Woerner, 2004; Perry et al., 2004). All of these studies with young children found improvements in their F&V consumption relative to a control group (i.e., between 0.14 and 0.58 servings), Auld et al. (1998) used non-school personnel (i.e., special resource teachers and parents) to implement their program, Perry et al. (2004) made changes to the F&V that were provided to students in the cafeteria, and Horne et al. (2004) implemented a token economy where lunch aides gave students hand stamps when they ate some of their F&V and then teachers gave students with hand stamps small prizes after lunch. Hendy, Williams, and Carnise (2005) also used a token economy system with older students, but their intervention was implemented by study researchers, who provided prizes contingent on F&V consumption.

The use of rewards contingent upon food consumption is controversial, as it has been shown to decrease children's food preferences (Birch, Marlin, & Rotter, 1984).

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To avoid “overjustification effects,” whereby children’s intrinsic motivation to eat F&V would be reduced as a result of external reinforcement (Lepper, Greene, & Nisbett, 1973), Hendy et al. (2005) used small and delayed reinforcement, provided reinforcement contingent upon a few bites of the target food, and incorporated peer participation and modeling. They demonstrated that children did *not* report decreased preferences for F&V at follow-up. Whereas the use of token economy systems appeared effective in the Horne et al. (2004) and Hendy et al. (2005) studies, the extent to which this type of intervention can be sustained by school staff over time is questionable. Therefore, it is important to investigate the effectiveness, fidelity, and acceptability of reinforcement-based interventions that are simpler to use, require fewer resources, and are implemented over time by school staff, rather than research personnel. Given the potential for schools to help children increase F&V consumption, there is a need to design effective programs that are affordable, acceptable, feasible, and sustainable.

The purpose of this study was to examine the impact of a multi-year, multi-component, school-based F&V promotion program on students’ F&V consumption during school lunch. Unlike previous studies, this study did not modify the type of food served in the cafeteria, but instead used a reinforcement-based intervention that was contained in the cafeteria and implemented by school staff. This study is one of the very few school-based efforts to include children as young as kindergarten. It was anticipated that our program would be perceived as acceptable and feasible, and it was hypothesized that students participating in the program would demonstrate greater F&V consumption relative to students in a control group. Second, it was hypothesized that students in the experimental group would demonstrate sustained increases in F&V consumption over time.

Method

Participants and Setting

This study was conducted in a large, urban school district in the Northeastern part of the United States. All kindergarten and first grade children attending four public schools were invited to participate in the spring and fall 2005. Parents provided written consent (56% experimental group; 45% control group; $N = 297$) for their child to participate. Demographic information about the sample is summarized in Table I. Participating school staff who served as interventionists included: (a) lunch aides ($n = 12$; 6/cafeteria); (b) classroom and computer teachers

Table I. Participant Demographic Information by Group

	Group	
	Experimental ($n = 149$)	Control ($n = 148$)
Participation rate (%)	56	45
Percentage of attrition		
Pre-intervention to Year 1 ^a	3	5
Year 1 to Year 2 ^a	20	29
Mean age in years (<i>SD</i>)	6.2 (0.53)	6.2 (0.60)
Gender (% boys)	51	51
Race/ethnicity (%)		
African American	29	36
Latino	41	51
Asian ^b	24	0
White	3	4
Other	2	9
Parent born outside United States (%) ^b	74	55
Non-English spoken at home (%) ^b	70	40
Children eligible for free or reduced price lunch (%)	94	88
BMI-for-age <i>z</i> -score at pre-intervention	0.80 (1.13)	0.93 (1.07)

^aAttrition was due to students moving to a new school.

^bGroups are significantly different.

($n = 24$); (c) principals ($n = 2$); and (d) athletic coaches ($n = 4$; full-time staff who promoted physical activity). The ratio of lunch aides to students in the cafeteria was 1:30. There were approximately 90 students in each lunch period. With the exception of the athletic coaches, all interventionists were employed by the school district.

School-Based Fruit and Vegetable Promotion Program (F&VPP)

Based in social learning theory (Bandura, 1977), the program included school-wide, classroom, lunchroom, and family components to promote F&V consumption with an emphasis on F&V in the school lunch (Blom-Hoffman, 2008). Program components were designed to capture students’ attention and to increase retention of F&V nutrition information by having influential role models (i.e., cartoon characters, videos with same age peers, the school principal, coaches) deliver consistent information across multiple settings. The program was designed: (a) to include repetition of messaging across settings, modalities, and messengers; (b) to use symbolic and live role modeling; (c) to incorporate vicarious and direct reinforcement; and (d) to be implemented entirely by school staff. Given the heavy demands placed on school staff, the program was designed to have many school staff members take on very minor roles related to program delivery. In this manner, staff members were not burdened

by their roles related to program implementation and children were surrounded by the program across multiple settings at school.

The school-wide component included loudspeaker announcements providing an interesting fact about the “F&V of the day.” The announcement was made by a high profile, respected adult in the school (i.e., the school principal or coach) and was designed to increase students’ attention to the messages. There was no cost associated with this component.

The classroom component included the 5-A-Day Adventures CD-ROM (Dole Food Company, 2000) used during computer classes. The computer program delivered health information to students via attractive, engaging cartoon characters and videos with same age peers. The characters and child actors served as symbolic role models for children in the study. There was no cost associated with this component as the CD-ROM was available to schools free of charge.

The lunchtime component involved hanging cafeteria posters reflecting the F&V of the day, and lunch aides “catching” students eating F&V by giving them verbal praise and a sticker contingent on one bite of these foods. The cafeteria posters, which changed daily to reflect the F&V being served that day in the school lunch, incorporated the cartoon characters from the classroom component and were placed as close to the cafeteria line as possible, so as to be visible as students were making decisions about whether or not to take a serving of fruit or vegetables. The attractive, engaging characters were intended to serve as symbolic role models to students and to capture their attention while they were standing on the cafeteria line. The “caught eating F&V” component was a reinforcement-based intervention that was designed to capitalize on the effects of peer role modeling and vicarious learning. Students observed peers being reinforced for taking a bite of a fruit or vegetable with stickers that incorporated the cartoon characters from the CD-ROM or F&V drawings designed by the students. Costs associated with this component were \$0.04/sticker and a one-time cost of approximately \$100 to print the posters.

The family component involved a series of interactive children’s books assigned as homework, the *5-A-Day Kids Cookbook* (Dole Food Company, 2004), and a school cookbook developed by children, parents and teachers, which was used as a fundraiser (Blom-Hoffman, Wilcox, Dunn, Leff, & Power, 2008). The five interactive children’s books were designed to: (a) reinforce a simple health message that students learned in school; (b) communicate consistent health information to caregivers; and (c) provide

a context for caregivers and children to discuss health information together. Unlike other modes of delivering nutrition information to families (e.g., newsletters or workshops), the interactive children’s books, which were assigned as homework, provided a cost effective, time efficient mechanism to deliver health information to large numbers of families in the comfort of their homes. Activities in the books included goal setting, self-monitoring, and symbolic role modeling with the cartoon characters, and each book cost approximately \$3.38 (Blom-Hoffman et al., 2008).

Measures

The study design was longitudinal with measurements collected in the winter 2006 (Pre-intervention), spring 2006 (“Year 1”) and spring 2007 (“Year 2”), except where otherwise noted. Table II summarizes the data collected from this study.

Intervention Monitoring and Fidelity

Unannounced intervention fidelity checks were conducted by a research assistant (RA) to assess the extent to which lunch monitors implemented the lunchtime components of the intervention (i.e., providing stickers contingent on a bite of fruit or vegetable and hanging up the correct F&V of the day). Direct observations were recorded on a fidelity checklist. Fidelity of the lunchtime observations for each school was expressed as a percent of days the lunchtime components were observed to be implemented. Morning announcements were recorded in a log by the school staff member who made them, and the percent of school days that morning announcements were made was calculated.

Acceptability Questionnaires

Intervention acceptability refers to the degree to which interventionists find an intervention appropriate, fair and reasonable (Witt & Elliott, 1985). Lunch aides and classroom teachers completed acceptability questionnaires (Blom-Hoffman, 2008). At the end of both years participating lunch aides completed a 10-item acceptability questionnaire using a six-point scale (1 = *strongly disagree*; 6 = *strongly agree*; $\alpha = .85$) to report their perceptions of the lunchtime component. A sample item included: “Giving stickers to students when they eat their fruits and vegetables during lunch is a good way to help them eat more fruit and vegetables.” Teachers completed a 17-item questionnaire using the same six-point scale described above ($\alpha = .89$) at the end of both intervention years. A sample item included: “The fruit and vegetable stickers are an acceptable way to encourage students to eat more fruit and vegetables during school lunch.”

Table II. Data Collection Measures, Source, Wave, and Sample Size

Measure	Data source	Data collection wave	Sample size	
			Experimental	Control
Fruit intake	Students	Pre-intervention	128	123
		Year 1	127	123
		Year 2	113	97
Vegetable intake	Students	Pre-intervention	131	115
		Year 1	128	120
		Year 2	113	96
Adapted Fruit and Vegetable Preference Questionnaire (A-FVPQ)	Students	Pre-intervention	135	130
		Year 1	131	105
		Year 2	113	99
BMI-for-age z-scores	Students	Pre-intervention	148	145
Gender	Students	Pre-intervention	149	148
Race/ethnicity	Parents	Pre-intervention	99	91
School	Design	Pre-intervention	149	148
Parent questionnaire	Parents	Pre-intervention	101	95
Student acceptability	Students	Year 1	113	N/A
		Year 2	95	
Teacher acceptability	Teachers	Year 1	15	N/A
		Year 2	14	
Lunch aide acceptability	Lunch aides	Year 1	12	N/A
		Year 2	9	

Child Questionnaire

Children also completed a brief questionnaire containing both open and closed-ended responses. Children used a three-point pictorial rating scale to report responses to four closed ended questions that assessed their perceptions of the program. Sample items included: “How much do you think the stickers help you eat your fruit and vegetables at lunch?” and “How much did you like getting stickers?” Open-ended questions were designed to examine children’s awareness of the intervention. For example, children who indicated they received stickers at lunch were asked “What did you have to do to get the lunch stickers?” This information was elicited to provide additional evidence above and beyond the fidelity checks that the intervention was being implemented as intended.

Child F&V Preferences

Child-reported F&V preferences were assessed using an adapted version of the Fruit and Vegetable Preference Questionnaire (A-FVPQ). The original questionnaire was developed by Domel, Baranowski, Davis, Leonard, Riley, & Baranowski (1993) to assess older students. Blom-Hoffman, Dai, & Franko (2004) adapted this questionnaire by including food photographs and a three-point (0 = *does not like*, 1 = *likes a little*; 2 = *likes a lot*) pictorial response card similar to that described by Birch and Sullivan (1991), and examined the psychometric properties of the adapted

questionnaire with a separate sample of 5 to 7-year-old children. The A-FVPQ consisted of 20 items (11 fruits; nine vegetables). Students were shown a picture of each food item and were asked to report how much they liked the food using the pictorial scale. Scores on the fruit preference scale ranged from 0 to 22, and scores on the vegetable preference scale ranged from 0 to 18. The A-FVPQ had acceptable internal consistency (vegetable scale $\alpha = .66$; fruit scale $\alpha = .68$), test-retest reliability (vegetable ICC = .79; fruit ICC = .72), and convergent validity (assessed by having students sort fresh fruits and vegetables from the questionnaire according to their preferences: total fruit preference ICC = .72; total vegetable preference ICC = .80).

Weighed Plate Waste

Direct measurements of student lunchtime F&V intake were used as the primary dependent variable to assess F&V consumption. Assessments were conducted in the four school cafeterias on three days within each data collection phase, so that a total of 36 days of data were collected. Across each school and each data collection phase assessments were scheduled to sample a range of consistent, similar foods (i.e., cooked green vegetable, raw vegetable, cooked corn, fresh and canned fruit). Prior to each data collection lunch period, three school lunches were purchased to determine the average portion

sizes served. In every instance processed fruit was purchased from foods already portioned out in containers for students and whole, fresh fruits were randomly selected from serving bins. In most cases vegetables were purchased from trays on the lunch line that were already portioned out for students. In some cases when vegetables were not pre-portioned, cafeteria staff, blind to study purposes, group assignments, and hypotheses, was asked to provide the portion of the vegetable to the research staff that students would receive on a lunch tray. In these cases, the same serving utensil that was used to serve children was used to portion the sample servings.

The average fruit portion served in the schools was 92 g (range = 88–95) and the average vegetable portion served was 55 g (range = 54–56). A one-way analysis of variance was conducted to explore differences in fruit and vegetable portion size across the three time points. There was no statistically significant difference in the portion sizes served to children for fruit [$F(2,45) = 0.45$, $p = \text{ns}$] or vegetables [$F(2,32) = 0.46$, $p = \text{ns}$] across the three time points. According to the FDA, the average fruit serving size is 140 g and vegetable serving size is 85 g (Eldridge, Smith-Warner, Lytle, & Murray, 1998). These figures were used to calculate changes in consumption in terms of portion and serving size.

Trained RAs, blind to study purposes, hypotheses and group assignments, observed children throughout the lunch period and collected trays. All children wore nametags so RAs were able to identify them. When students were finished eating they were instructed to place their nametag on their tray. While observing children in small groups, RAs recorded each of the foods on the trays. To assess reliability of direct observations, two independent RAs simultaneously observed 23% of students across the study. Kappa coefficients for fruits (range = .69–.86) and vegetables (range = .86–.93) ranged from “moderate” to “nearly perfect” agreement.

At the end of the lunch periods, trays of students who took the school lunch (Pre-intervention = 97%; Year 1 = 97%; Year 2 = 98%) were weighed on a food scale that was accurate to 1 g (Salter Model 2006, Kent, England). Only foods served in the school lunch were measured. The scale was checked for accuracy using calibration weights. Each fruit and vegetable was weighed separately. Food intake was calculated as follows: Initial mean portion served in grams minus amount of food left on the tray in grams.

Caregiver Questionnaire

At Pre-intervention, primary caregivers ($n = 196$; 66%) were interviewed by phone in their native language

(English, Spanish, Vietnamese) by a native speaker, who used a structured questionnaire to obtain demographic information, including child race and ethnicity.

Child BMI

The lead author weighed and measured all of the children, who removed their shoes and sweaters. Anthropometric techniques followed those described by Lohman, Roche, and Martorell (1988). Weight was measured to 0.1 kg (Seca digital electronic scale, Creative Health Products, Plymouth, MI). Standing height was measured to 0.1 cm with a portable stadiometer (Shorr Productions, Olney, MD). BMI-for-age z-scores were calculated using EpiInfo (CDC, 2004), which used normative data from the CDC 2000 reference growth charts (Ogden et al., 2002).

Procedures

The four elementary schools were selected to participate in this study because they were already collaborating with the university on a physical activity promotion initiative for older grades. The schools were randomly assigned to condition (i.e., experimental or control). The study was approved by the Institutional Review Board at Northeastern University and by the school district's research office. Multiple participant recruitment procedures were used in this study (Blom-Hoffman, Leff, Franko, Weinstein, Beakley, & Power, 2009). These procedures included increasing communication about the study between the principal investigator and the school staff and students, sending consent forms home for parents to sign, and setting up a class-wide reinforcement system designed to reward returned consent forms regardless of parents' willingness to have their child participate in the study. Although parental consent was required for students' to participate in the outcome evaluation, all students received the program. School staff was not aware of which students had obtained parental consent and which had not.

Following recruitment, Pre-intervention data were collected. Students' height and weight were measured, the A-FVPQ was administered, and BMI and plate waste data were collected. The program was implemented continuously in the two experimental group schools between the winter 2006 and spring 2007. Data collection procedures were repeated in the spring 2006 (Year 1) and the spring 2007 (Year 2). All measures used in this study along with the source of information, administration period, and sample size associated with each measure are described in Table II.

Interventionist training was conducted by the first author, who met with teachers individually or in small

groups to demonstrate the use of the CD-ROM and with lunch monitors as a group prior to implementation of the “caught eating F&V” intervention. Lunch monitors and first author discussed the importance of helping children eat F&V in the school lunch and the lunch monitors’ desire to help students improve their eating. The “caught eating F&V” component was described, sample stickers were shared, and lunch monitors determined how it would be best implemented in their cafeteria. Following this initial meeting, the first author observed the initial day of implementation and provided feedback to the lunch monitors. The RA who conducted fidelity checks provided additional stickers when needed. At the end of each year, a wrap-up meeting with the lunch monitors was held.

Statistical Analyses

In this study, students were nested within schools and data were collected for each student at multiple time points. Analyses were conducted at the time point (within-student) level, taking into account the repeated measurements within students. School was treated as a fixed effect (i.e., differences among school means were modeled) rather than as a random effect (modeling the correlation among students within schools), due to the small number of schools, making it unlikely that random school effects could be accurately estimated (Brown & Prescott, 1999). Hierarchical linear modeling (HLM) was used to analyze the data, due to the ability of HLM to accommodate repeated measures and to handle missing data that are inevitable in longitudinal analyses (Beunckens, Molenberghs, & Kenward, 2005; Bryk & Raudenbush, 1992; Verbeke & Molenberghs, 2000). A separate model was constructed for the amount of fruit consumed (intake in grams) and the amount of vegetables consumed (intake in grams). Group differences in each measure Y_{ij} (i denotes yearly measures within students and j denotes students) after the intervention (Years 1 and 2) were modeled as follows:

$$Y_{ij} = \beta_{0j} + \beta_1 * X_{1j} + \dots + \beta_n * X_{nj} + r_{ij}$$

where $\beta_{0j} = \gamma_{00} + u_{0j}$ (a student-specific intercept term); $\text{Var}(r_{ij}) = \sigma^2$ (the estimated variance within students); $\text{Var}(u_{0j}) = \tau_{00}$ (the estimated variance between students).

In the model equation, β_{0j} is an intercept term, β_1 is the estimated effect of group and β_2 through β_n represent the estimated effects of a set of adjustment variables, specifically the dependent variable measured at pre-intervention and sex, race/ethnicity, BMI z-score, F&V preference, and school. Model estimates are interpreted as estimated fruit/vegetable consumption in Years 1 and 2

after statistically controlling for differences in the amount consumed at pre-intervention and the other adjustment variables. A sustained intervention effect is indicated by a significant group difference in both Years 1 and 2; an unsustained or temporary intervention effect is indicated by a significant group difference in Year 1 but not in Year 2. Hierarchical linear models (PROC MIXED in SAS v.9.1.3, SAS Institute, Cary, NC) were used to account for the repeated measurements (Verbeke & Molenberghs, 2000). A random intercept was modeled and all other effects were fixed.

There were missing data at pre-intervention and follow-up time points. Preliminary analyses showed that the data were not missing completely at random (Rubin, 1987), therefore handling the missing data by excluding observations with missing values would not be a valid approach. Simple forms of imputation (e.g., median imputation, last-observation-carried-forward) were ruled out because they can lead to biased estimates (Allison, 2002). Multiple imputation (PROC MI and MIANALYZE in SAS) was selected to handle missing data because in longitudinal clinical trials involving missing observations at baseline as well as at follow-up, multiple imputation produces more accurate estimates than standard methods for handling missing data (Tang, Song, Belin, & Unutzer, 2005). Briefly, multiple imputations involve replacing each missing data point with several plausible values that are estimated based on regression using the non-missing data points, with an element of randomness added to the imputation. This enables efficient use of data from participants who failed to complete some measurements (as opposed to excluding such participants from the analysis), while at the same time adjusting for the uncertainty arising from the fact that some data are being imputed.

Diagnostics indicated that all models were reasonably consistent with statistical assumptions. Additional models were estimated using F&V preference as the dependent variable, utilizing the same analytic techniques as in the intake models. The amount of fruit consumed was compared with the amount of vegetables consumed using paired t -tests, a separate test for each study year. All tests of significance were two-sided and performed at the $\alpha = .05$ level. The intra-class correlation (ICC) is reported as an estimate of the proportion of the variance in F&V consumption that was between as opposed to within students [$\text{ICC} = \tau_{00}/(\tau_{00} + \sigma^2)$; Bryk & Raudenbush, 1992], after taking the adjustment variables into account. Cohen’s d , interpreted as the standardized difference between groups, was used as an indicator of effect sizes; as a rule of thumb, d values around .2 have

been considered “small,” .5 are “medium,” and .8 are “large” (Cohen, 1988).

Results

Sample and Attrition

The study sample was racially and ethnically diverse (Table I). In both the experimental and control groups many children had a parent born outside the United States and non-English languages were spoken in the homes. Children’s BMI-for-age z-scores, age in years and gender were similar between the two groups. The experimental group had more Asian children, more children with a parent born outside the United States, and more non-English spoken at home. There was significant attrition between Year 1 and Year 2 data collection waves because many students transferred to other non-study schools.

Process Evaluation

Fidelity checks for the lunchtime components were conducted on 24% and 16% of school days in Years 1 and 2, respectively. In both years, integrity for the “caught eating F&V” lunchtime procedures was high (88% of days checked in Year 1 and 94% of days checked in Year 2). The correct F&V of the day poster was hung on 62% and 59% of days checked in Years 1 and 2, respectively. According to school logs, morning announcements were made on 91% and 65% of school days in Years 1 and 2, respectively.

Children’s perceptions of the F&V program were positive. Almost all children (98%) reported hearing the morning announcements. Most reported liking the announcements “a lot” (78%). Nearly all students reported receiving the lunchtime stickers (94%). Almost all students reported either that they need to eat F&V (75%) or “eat healthy” at lunch (19%) to receive a sticker. Many students reported that the stickers helped them eat their F&V “a lot” (87%), and they liked receiving the stickers “a lot” (73%).

Most lunch aides completed the acceptability questionnaire at the end of Years 1 (100%) and 2 (75%). On the six-point scale, lunch aides rated the program as highly acceptable (Year 1: $M = 5.62$; $SD = 0.65$; Year 2: $M = 5.67$; $SD = 0.39$). Moreover, in both years 100% of the lunch aides reported that they “strongly agreed” that giving stickers helped the children to eat more F&V in the school lunch.

Most teachers completed the acceptability questionnaire in Years 1 (100%) and 2 (88%). Using the six-point scale, teachers rated the program as highly

acceptable (Year 1: $M = 5.51$; $SD = 0.38$; Year 2: $M = 5.34$; $SD = 0.50$). Only one teacher reported a negative side effect from the program. She was concerned that the program’s emphasis on increasing F&V consumption may have inadvertently communicated that the other foods were less important.

Student F&V Preferences

Students’ fruit preferences were higher than their vegetable preferences across all three time points, and preferences were remarkably stable across time (fruit preference range $M = 18.54$ – 18.78 ; $SD = 5.54$ – 3.03 ; vegetable preference range $M = 11.43$ – 11.56 ; $SD = 2.93$ – 3.06). After adjusting for Pre-intervention fruit and vegetable preferences, the study groups did not differ in preference for fruit in either Year 1 or Year 2 (Experimental minus control fruit preference, Year 1 = 0.10, 95% CI: $-1.01, 1.21$, $p = .85$; Year 2 = 0.33, 95% CI: $-0.63, 1.29$, $p = .50$), nor were there any group differences in vegetable preferences in Years 1 or 2 (Experimental minus control vegetable preference, Year 1 = 0.24, 95% CI: $-1.00, 1.48$, $p = .69$; Year 2 < 0.01, 95% CI: $-1.02, 1.03$, $p = .99$).

Group Differences in Fruit and Vegetable Consumption

Means for the F&V consumption measures by study group and year are shown in Table III. Preliminary analyses showed that at pre-intervention, the groups differed only on vegetable intake, which was about 3 g/lunch greater among children in the experimental group ($p < .05$). All remaining analyses examining group differences statistically controlled for F&V intake at Pre-intervention.

Group Differences in Fruit Consumption

Children in the experimental group consumed more fruit compared with children in the control group in Years 1 and 2 of the program. In Year 1 children in the experimental group consumed 29 more grams of fruit per lunch (95% CI: 21–38 g, $p < .0001$, Cohen’s $d = .86$, ICC = .09; 0.32 portions/lunch; 0.21 serving/lunch) compared with children in the control group. In Year 2, children in the experimental group consumed 21 more grams of fruit per lunch (95% CI: 10–32 g, $p < .0005$, Cohen’s $d = .55$; 0.23 portions/lunch; 0.15 serving/lunch) compared with children in the control group.

Group Differences in Vegetable Consumption

In Year 1 children in the experimental group consumed 6 more grams of vegetables per lunch (95% CI: 2–11 g, $p < .01$, Cohen’s $d = .34$, ICC = .15; .11 portions/lunch; .07 servings/lunch) compared with children in the

Table III. Mean (95% CI) and for Measures of Fruit and Vegetable Consumption by Study Group and Year

Consumption measure	Study year			
	Group	Pre-intervention	Year 1	Year 2
Fruit intake (g)	Experimental	27 (22, 32)	45 (40, 51)***	34 (30, 39)***
	Control	29 (24, 34)	26 (21, 31)	23 (18, 28)
Vegetable intake (g)	Experimental	11 (9, 13)*	18 (15, 20)**	15 (12, 17)
	Control	8 (7, 10)	8 (6, 10)	9 (7, 11)

Note. Multiple imputations were used to handle missing data. Significant differences between the experimental and control groups are noted as follows: *** $p < .001$; ** $p < .01$; * $p < .05$.

control group. However, in Year 2, grams of vegetables consumed did not differ between the groups.

Discussion

The multi-component, school-based program was implemented with good levels of integrity and resulted in increased F&V consumption. At the end of Year 1, children in the experimental group ate 0.43 additional portions and 0.28 additional servings of F&V per day served in the school lunch. This finding is consistent with the review of Knai et al. (2006), which found that among the 15 studies examined, 10 demonstrated increased F&V consumption, ranging from 0.30 to 0.99 servings per lunch. The effect of the current study was reduced at the end of Year 2 with students in the experimental group eating 0.23 additional portions of fruit (0.15 additional servings) and no additional vegetables with children in the control group. These changes are consistent with other research findings in this area, and are important from a public health perspective as they represent a sustained increase in fruit consumption at the group level.

Although it is impossible to identify the main variable(s) responsible for student behavior change, it is likely that the intermittent reinforcement component implemented at the point of performance played a major role in increasing students' consumption. Although the other program components are probably less important in terms of impacting behavior change, they provided a context for the lunchtime component. The CD-ROM and cafeteria posters helped the students identify where the F&V were located in their school lunch; the cafeteria poster reminded the students to take F&V on their lunch tray, the loudspeaker announcements and CD-ROM motivated the students to eat F&V by raising the profile of these foods on an on-going basis, and the family component helped to bring the messages home.

Fidelity checks for the lunchtime components indicated that integrity for the reinforcement procedures

was very high; however, the extent to which the correct F&V of the day was hung on the posters was lower. It is possible that the high degree of integrity for the reinforcement component may have been inflated due to lunch monitor reactivity to the presence of the RA. However, anecdotal comments from teachers and administrators regarding the frequency that stickers were given out, the high rate with which the sticker supply needed to be refilled, and student responses on the questionnaire that they needed to eat a fruit or vegetable at lunch to receive a sticker all provided further evidence that stickers were given out at a high rate contingent on F&V consumption. The lower rates of fidelity for the posters were primarily due to difficulties with the coaches implementing this component of the program. These difficulties were resolved by having the lunch monitors take over the implementation of this component at one school. Notably, when this modification was made, fidelity was nearly perfect.

Blanchette and Brug (2005) found three variables most strongly related to F&V consumption: availability, accessibility, and taste preference. Experimental studies have indicated that when children are given repeated opportunities to taste unfamiliar foods, increases in preference and consumption occur (Cooke, 2007). In this study F&V consumption during school lunch increased without concurrent increases in F&V preferences. Consistent with prior studies (Horne et al., 2004; Perry et al., 2004), the encouragement to try F&V by lunch aides may have contributed to increased intake. Increased F&V consumption in the absence of increased preferences can be explained by the fact that almost all of the behavior change was related to increased fruit consumption and children reported very high levels of fruit preference at all three time points, making it difficult to increase fruit preferences further. The program did not directly target increasing students' preferences for vegetables. Future research should focus on addressing barriers to student vegetable consumption in the school lunch (e.g., palatability of the foods served). A thorough understanding of students' perceptions of barriers interfering with vegetable

consumption should be sought and incorporated into the design of future programs.

Importantly, although our program incorporated reinforcement contingent upon student eating behavior, we were able to avoid overjustification effects (Lepper et al., 1973). Students' reports of F&V preferences remained highly stable across the 15-month period, indicating that the program did not adversely impact or increase their F&V preferences. Also, students reported high levels of program acceptability, suggesting that they were still motivated by the program and satiation effects did not occur.

Study Limitations and Strengths

Limitations included the lack of longer term follow-up data, no attention control group, some attrition, moderate participation rates, and the potential for inflated acceptability reports due to social desirability. However, the latter concern was minimized by having teachers and lunch monitors complete the questionnaires anonymously and return them by mail. In this study direct measurement of consumption only occurred during school lunch. However, recently published data indicated that for a sub-set of students in this study whose caregivers were able to be reached for three phone interviews, caregivers of children in the experimental group reported that their children ate more F&V than caregivers of children in the control group (Blom-Hoffman et al., 2008). Another limitation was related to the participation rate, which in this study was slightly lower than the average participation rates found in school-based intervention and prevention studies that use active parental consent and reported participation rates (Blom-Hoffman et al., 2009). Finally, we do not know if the intervention strategies used in this study are relevant for older elementary school students.

These limitations are off-set by several strengths. This study involved a theory-based, cost effective method to reinforce a racially and ethnically diverse group of young children for their F&V consumption over 15 months. This is one of the only school-based F&V promotion studies that included children as young as kindergarten. School staff served as interventionists and the reinforcement system was simple, acceptable, and confined to the cafeteria setting. The longitudinal design allowed us to assess program decrement over time. The study included a precise, direct assessment of student consumption using weighed plate waste and our statistical modeling controlled for multiple confounders in the analyses. The study also included a careful process evaluation that assessed program implementation and acceptability.

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